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ABSTRACT

The course outline has been prepared as a guide to assist the instructor in systematically planning and presenting a variety of meaningful lessons to facilitate the necessary training for the machine shop student. The materials are designed to enable the student to learn the manipulative skills and related knowledge necessary to understand composition of metals and alloys, basic metallurgy, surface texture, cutting actions of metal, and heat treatment of steel. Prior to entry to this course, the student must display a mastery of the skills indicated in "Abrasives and Grinding Machines." This is the third Quinmester course of the second year, consisting of five blocks of instruction subdivided into several units each. This course is 135 hours in length. By satisfactorily completing this course, the student can advance to the next course in the series needed to obtain the skills and technology of the machinery trades. Posttests and a bibliography are appended. (Author/AJ)

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AUTHORIZED COURSE OF INSTRUCTION FOR THE QUINMESTER PROGRAM

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V-182

Course Outline
MACHINE SHOP WORK 3 - 9557
(Metals and Alloys)
Department 48 - Quin 9557.03

CE 002 101

DADE COUNTY PUBLIC SCHOOLS
DIVISION OF INSTRUCTION • 1973

ED.096489

D A D E C O U N T Y P U B L I C S C H O O L S

1 4 5 0 N O R T H E A S T S E C O N D A V E N U E

M I A M I, F L O R I D A 33132

Course Outline

MACHINE SHOP WORK 3 - 9557
(Metals and Alloys)

Department 48 - Quin 9557.03

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Dade County Public Schools
Miami, Florida 33132

April, 1973

Published by the School Board of Dade County

PREFACE

The following quinmester course outline has been prepared as a guide to assist the instructor in systematically planning and presenting a variety of meaningful lessons programmed to facilitate the necessary training for the machine shop student.

The materials contained in this outline are designed to enable the student to learn the manipulative skills and related knowledge necessary to understand composition of metals and alloys, basic metallurgy, surface texture, cutting actions of metal and heat treatment of steel.

Prior to entry into this course, the student must display a mastery of the skills indicated in Quin 9557.02. This is the third quinmester course of the second year, consisting of five blocks of instruction, which are subdivided into several units each. This course is 135 hours in length.

The classroom instruction includes lectures, demonstrations, group discussion, study periods, and use of various audiovisual aids.

By satisfactorily completing this course, the student can advanced to the next course in this series needed to obtain the skills and technology of the machinery trades.

This outline was developed through the cooperative efforts of the instructional and supervisory personnel, the Quinmester Advisory Committee, and the Vocational Curriculum Materials Service, and has been approved by the Dade County Vocational Curriculum Committee.

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with Suggested Hourly Breakdown

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Cutting Fluids	1
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GOALS

The student must be able to demonstrate:

1. Familiarity with shop equipment, materials, and regulations regarding school, shop, and safety; and an awareness of the employment opportunities in the machine trades.

2. Knowledge of determining basic finishes on metals by comparison of specimens.

3. By manipulation, the cutting action on metal and cutting fluids on tools, while operating machinery in a safe and productive manner.

4. A basic knowledge of metals, alloys, metallurgy, heat treatment, safety regulations, methods and a minimum measurable proficiency in hardening, tempering and annealling of steel.

SPECIFIC BLOCK OBJECTIVES

BLOCK I - SURFACE TEXTURE

The student must be able to:

1. Identify in writing surface texture values and symbols.
2. Exhibit the ability to check surface finishes by comparison of specimens.

BLOCK II - CUTTING ACTION AND CUTTING FLUIDS

The student must be able to:

1. Explain orally the action of the cutting tool and types of chips produced.
2. Demonstrate, manually, the use of cutting fluids.
3. List the cutting tool materials and their proper uses.

BLOCK III - METALS AND ALLOYS

The student must be able to:

1. Explain in writing the classification of metals and alloys and their mechanical properties.
2. Define in writing the basic processes and furnaces used in making pig iron, cast iron, steel, carbon steel, alloy steel, and non-ferrous alloys.

BLOCK IV - BASIC METALLURGY AND HEAT TREATMENT OF STEEL

The student must be able to:

1. Demonstrate by performance the ability to work safely with heat treating equipment.
2. List in writing the various forms of heat treating steel processes, heat inducing media, heat quenching media and methods of measuring the hardness of steel.
3. Demonstrate his proficiency in heat treating steel by correctly performing the processes of hardening, tempering, annealing, and normalizing within industrial standards.
4. Exhibit manually the ability to set up a Rockwell tester and obtain, accurately, a hardness reading on the "C" scale.

BLOCK V - QUINMESTER POST-TEST

The student must be able to:

1. Satisfactorily complete the quinmester post-test.

Course Outline

MACHINE SHOP WORK 3 - 9557
(Metals and Alloys)

Department 48 - Quin 9557.03

I. SURFACE TEXTURE

- A. Specifications
  - 1. Standards
  - 2. Related terms
  - 3. Symbols
- B. Checking
  - 1. Comparison specimens
  - 2. Roughness indicator

II. CUTTING ACTION AND CUTTING FLUIDS

- A. Action of a Cutting Tool
- B. Types of Chips
- C. Cutting Fluids
  - 1. Coolant
  - 2. Lubricant
  - 3. Reduction of tool wear
  - 4. Function in grinding
  - 5. Classification
    - a. Cutting oils
    - b. Emulsifiable oils
    - c. Other cutting fluids and coolants
  - 6. Selection
- D. Cutting Tool Materials
  - 1. Properties
    - a. Hardness at high temperatures
    - b. Wear resistance
    - c. Strength
  - 2. Materials used
    - a. Carbon tool steel
    - b. High speed steel
    - c. Cast alloys
    - d. Cemented carbides
    - e. Ceramics
    - f. Diamonds

III. METALS AND ALLOYS

- A. Classification of Metals
  - 1. Alloy

2. Composition of alloys
    a. Elements
    b. Compounds
    c. Substances
    d. Mixtures
    e. Solutions

B. Properties of Metals
    1. Mechanical
        a. Hardness
        b. Hardenability
        c. Brittleness
        d. Ductility
        e. Malleability
        f. Toughness
        g. Machinability
        h. Strength
        i. Yield point
        j. Elongation
        k. Stress
        l. Reduction of area
        m. Strain
        n. Elasticity
        o. Elastic limit
        p. Plasticity
        q. Fatigue
        r. Fusibility
    2. Chemical

C. Production of Iron
    1. Raw material
    2. Furnaces
        a. Blast
        b. Open hearth
        c. Basic oxygen
        d. Electric
        e. Bessemer converter
    3. Pig iron

D. Steel Making
    1. Processes
    2. Ingots
    3. Forms

E. Carbon Steels
    1. Pure iron
    2. Plain carbon steel
    3. Resulfurized carbon steel

F. Steel Classification and Identification
    1. SAE and AISI code
    2. Color code
    3. Spark test

III. METALS AND ALLOYS (Contd.)

G. Alloy Steels
   1. Classification
   2. Alloying elements
   3. Forms

H. Nonferrous Alloys
   1. Copper base
   2. Aluminum base
   3. Zinc base
   4. Magnesium base
   5. Nickel base
   6. Lead base
   7. Tin base
   8. Special

I. Cast Iron
   1. Gray
   2. White
   3. Malleable
   4. Ductile

IV. BASIC METALLURGY AND HEAT TREATMENT OF STEEL

A. Safety Precautions
   1. Personal
      a. Eye and face protection
      b. Hand protection
      c. Proper clothing
      d. Proper conduct
   2. Work hazards
      a. Hot objects
      b. Floor area
      c. Proper tongs

B. Introduction to Heat Treat
   1. Heat treatment and metallurgy
   2. Heat treatment process
   3. Furnaces
      a. Electric
      b. Gas
   4. Temperature control
      a. Pyrometer
      b. Thermocouple
   5. Temperature colors

C. Grain Structure of Steel

D. Carbon Content Affects Hardening

E. Quenching Media
   1. Air

2. Oil
3. Water
4. Brine

F. Tempering, Annealing and Normalizing
1. Processes
2. Temperatures
3. Determining toughness
4. Spheroidizing

G. Harden and Temper Steel
1. Process
2. Heating precautions
3. Procedure

H. Case Hardening Processes
1. Carburizing
2. Carbonitriding
3. Nitriding

I. Special Hardening Processes
1. Flame hardening
2. Induction hardening
3. Aus tempering

J. Hardness Testing
1. File
2. Rockwell
3. Brinnell
4. Shore scleroscope
5. Microhardness

V. QUIMESTER POST-TEST

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A P P E N D I X

Quinmester Post-Test Sample

Quinmester Post-Test

Name _____ Date _____ Score ____

Multiple Choice Test Items

Each statement needs a word, a figure, or a phrase to make it correct. Only one of the choices listed is correct. Place the letter of the choice you make in the space provided at the left edge of the sheet.

____ 1. The symbol 90% means the:

a. Minimum requirements for contact or bearing area with a mating part
b. Percentage of flaws permitted
c. Percentage of roughness-width variation permitted
d. Percentage of waviness height variation

____ 2. The following statement that is unrelated to the function of cutting fluids is:

a. Prevents any possible adhesion
b. Prevents any possible cohesion
c. Cooling of tool and work
d. Reduces tool wear

____ 3. A material that can be permanently deformed without rupturing or breaking is said to be:

a. Stress relieved
b. Annealed
c. Elastic
d. Plastic

____ 4. The greatest stress occurs in the cutting action sequence:

a. Along the shear plane
b. Along the work piece surface plane
c. In the chip
d. In the tool bit

____ 5. The characteristic structure of all metals in the solid state is:

a. Magnetic
b. Heavy
c. Crystalline
d. Hard

____ 6. A microinch represented by figures is:

a. 0.000,000,1
b. 0.000,01
c. .000,01
d. 0.000,001

____ 7. The lowest cost cutting tool material is:

a. High speed steel
b. Carbon tool steel
c. Cast alloy
d. Cemented carbide

____ 8. The property of cutting tool materials, to maintain hardness at elevated temperatures is known as:

a. High hardness
b. Redness
c. Red hardness
d. Hardenability

____ 9. The principal ingredients of ceramic tool materials are oxides of:

a. Silicon
b. Aluminum, silicon and magnesium
c. Aluminum, carbon and silicon
d. Aluminum and carbon

____10. Carbon tool steel cutting tools lose their hardness at temperatures of:

a. 600°-700° F
b. 800°-900° F
c. 400°-500° F
d. 1,000°-1,110° F

____11. The most heavily alloyed of all our steels is the:

a. High-speed steel type
b. Carbide type
c. Cast alloy type
d. Carbon tool steel type

____12. Which of the following is unrelated to the classification of high-speed tool steel types:

a. Cobalt
b. Tungsten based
c. Molybdenum based
d. Carbon based

____13. Cast alloys lose their hardness while cutting at temperatures of:

a. 1,100° F
b. 1,700° F
c. 1,300° F
d. 1,500° F

____14. Cemented carbide tools should be ground on wheels composed of:

a. Aluminum oxide
b. Emery
c. Silicon carbide or diamond
d. Garnet

____15. Cemented carbide tools tend to retain their hardness in the machining process to approximately:

a. 1,700° F.
b. 1,500° F
c. 1,300° F
d. 1,100° F

____16. Group C, of the cemented carbide, tool material, is designed to cut best:

a. Ferrous metals
b. Nonferrous metals
c. High-carbon steels
d. Die steels

____17. Ferrous metals are those metals which intentionally contain:

a. Iron
b. Carbon
c. Steel
d. Brass

____18. The following nonferrous metal is a copper base metal.

a. Aluminum
b. Titanium
c. Brass
d. Monel

____19. The characteristic behavior of metal when acted upon by external forces is explained as that metal's:

a. Physical properties
b. Mechanical properties
c. Hardness properties
d. Chemical properties

____20. A compound is a substance that, when compared to its elements in terms of their properties, the compound would be:

a. Higher in melting point
b. Higher in strength
c. Higher in toughness
d. Very different

____21. All metallic elements are in a solid state at room temperature except:

a. Iridium
b. Titanium
c. Platinum
d. Mercury

____22. Ductility is usually expressed as a percentage of elongation as well as a measure of:

a. Units of stretch per foot
b. Load per square inch
c. Strain in inch pounds
d. Reduction in area

____23. The Charpy and IZOD testers are used to measure a metal's:

a. Strength
b. Ductility
c. Toughness
d. Hardness

____24. Iron ore melts in the range of:

a. 2200° to 2500° F
b. 2100° to 2300° F
c. 2400° to 2600° F
d. 2000° to 2200° F

____25. In the Bessemer converter process, the condition of a heat is determined by the:

a. Length and color of the fire
b. Amount of oxygen used
c. Amount of air used
d. Temperature

____26. The high temperature of a blast furnace is:

a. 2000° F
b. 3000° F
c. 2500° F
d. 2200° F

____27. Steel is held to a high, even temperature for rolling at the:

a. Soaking pit
b. Transfer car
c. Holding oven
d. Pouring ladle

____35. The B.O.P. furnace resembles the Bessemer converter with the exception that the B.O.P. is faster as a result of using pure:

a. Nitrogen
b. Hydrogen
c. Oxygen
d. Natural gas

____36. The electric furnace produces higher temperatures faster than other processes plus the fact that:

a. Scrap is easier to control
b. Cost is lower
c. Flux can be better controlled
d. Atmosphere can be controlled more easily

____37. Prior to rolling, steel ingots must be brought to a uniform temperature of approximately:

a. 2400° F
b. 2200° F
c. 2000° F
d. 2600° F

____38. The steelmaking process that most steel industry is turning to is:

a. Basic oxygen process furnace
b. Open hearth furnace
c. Electric furnace
d. Bessemer converter

____39. A plain carbon steel with an average of 45 points of carbon in it would be numbered like which of the following:

a. 1160
b. 1035
c. 1045
d. 2145

____40. The two major systems for classifying standard constructional grades of steel are:

a. AISI and ASTM
b. SAE and AWS
c. ASTM and SAE
d. AISI and SAE

____41. The carbon content range of plain carbon steel is:

a. .05% to 1.7%
b. .001% to .05%
c. 1.7% to 2.7%
d. 2.7% to 4.7%

___42. The degree of increase in tensile strength of steel is caused by heat treatment combined with the content percentage in steel with:

a. Silicon
b. Carbon
c. Sulfur
d. Phosphorus

___43. Carbon content in steel is usually expressed in terms of:

a. Decimals
b. Fractions
c. Points
d. Percents

___44. The letter preceding the number, under the American Iron and Steel Institute's system of identifying steels, designates a:

a. Die type steel
b. Specific set of physical properties
c. Special alloying method is employed
d. Processing method

___45. The SAE 4140 steel is principally what alloy type?

a. Nickel
b. Nickel-chrome
c. Chromium
d. Molybdenum

___46. A controlled amount of sulfur is generally added to steel to improve the:

a. Weldability
b. Toughness
c. Machinability
d. Tensile strength

___47. Any iron-carbon mixture comes under a classification of cast iron when the carbon content exceeds:

a. 1.9%
b. 1.7%
c. 1.5%
d. 3.5%

___48. The heating and cooling of metal in its solid state for the purpose of changing its mechanical properties is called:

a. Heat treating
b. Annealing
c. Normalizing
d. Hardening

___49. The study of microscopic structures of metal is called:

a. Metallizing
b. Metallurgy
c. Metallography
d. Metrology

___50. According to the American Society for Testing Materials (ASTM) grain size chart, the finest grain pattern possible in the heat treatment of steel is 96 grains or more per square inch and is designated by the number:

a. 8
b. 3
c. 1
d. 12

___51. A thin section of high carbon steel can be most effectively quenched by agitating it in:

a. Air
b. Oil
c. Water
d. Brine

___52. The quenching medium that has the capacity of breaking and throwing off scale during the quenching procedure is:

a. Agitated water
b. Still water
c. Oil
d. Brine

___53. When manually quenching steel, the best agitation is achieved by a figure-eight movement or by:

a. An up-and-down movement
b. A circular movement
c. An in-and-out movement
d. A circular plus an in-and-out movement

___54. The process of introducing carbon into the surface layer of low carbon steel is called:

a. Cyaniding
b. Carburizing
c. Nitriding
d. Carbon nitriding

___55. The heat treatment process used to produce a hard, wear-resistant surface over and around a soft, tough core is:

a. Tempering
b. Hardening
c. Case hardening
d. Annealing

___56. The surface hardening process producing the hardest surface possible - RC 70-75 is:

a. Induction hardening
b. Carbon nitriding
c. Liquid cyaniding
d. Gas nitriding

___57. The heat treatment process which relieves stress, reduces brittleness and increases toughness is called:

a. Normalizing
b. Toughening
c. Annealing
d. Tempering

___58. A 3" thick part should be soaked at the tempering temperature for a period of:

a. 2 Hours
b. 3 Hours
c. 30 Minutes
d. 1 Hour

___59. Which of the following case hardening processes is considered extremely dangerous?

a. Liquid cyaniding
b. Gas nitriding
c. Pack carburizing
d. Gas carburizing

___60. Induction hardening depends on the localized generation of heat through:

a. Pressure and ultrasonics
b. Electromagnetism and high frequency.
c. High resistance
d. Gas combustion

___61. The slowest of the casehardening processes is:

a. Gas nitriding
b. Gas carburizing
c. Pack carburizing
d. Liquid cyaniding

___62. How many points of carbon are recommended for steel that is to be flame hardened:

a. 15
b. 45
c. 60
d. 30

____63. The process that heat treats to depths of 1/32" to 1/4" into metal surfaces of large difficult to move parts is:

a. Liquid cyaniding
b. Pack carburizing
c. Flame hardening
d. Gas carburizing

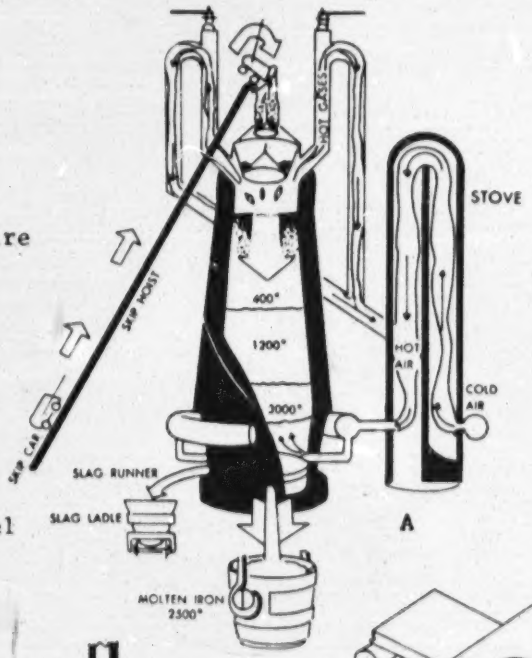
Quinmester Post-Test

Name _____ Date _____ Score ____

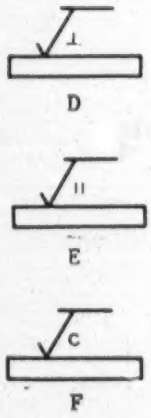
Identification Test Items

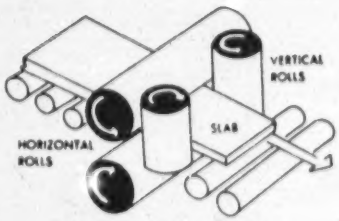
Examine the following symbols and sketches. Match the letter representing the symbol or sketch with the number, and place the letter in the space provided.

1. ____ Shear stress
2. ____ Blast furnace
3. ____ Continuous chip
4. ____ Rolled for rods and wire
5. ____ Electric furnace
6. ____ Discontinous chip
7. ____ Open hearth furnace
8. ____ Tension stress
9. ____ Casting ingots of steel
10. ____ Stripping molds
11. ____ Basic oxygen furnace
12. ____ Rolled for structural shapes
13. ____ Soaking to a rolling temperature
14. ____ Rolled for plate, sheet, and strip



A





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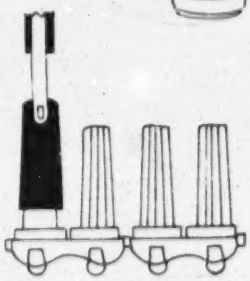
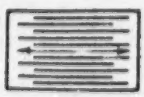
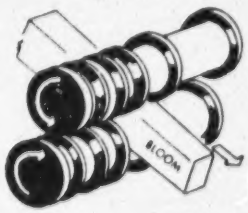

B

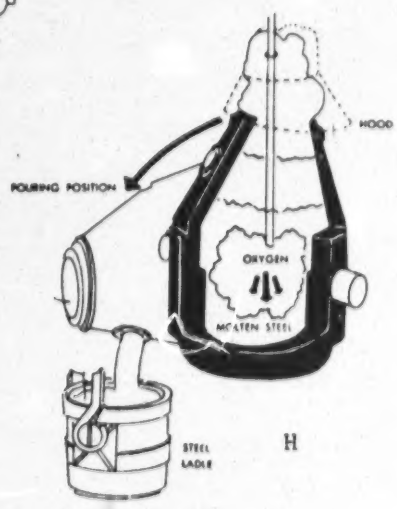
15. ____

16. ____ 

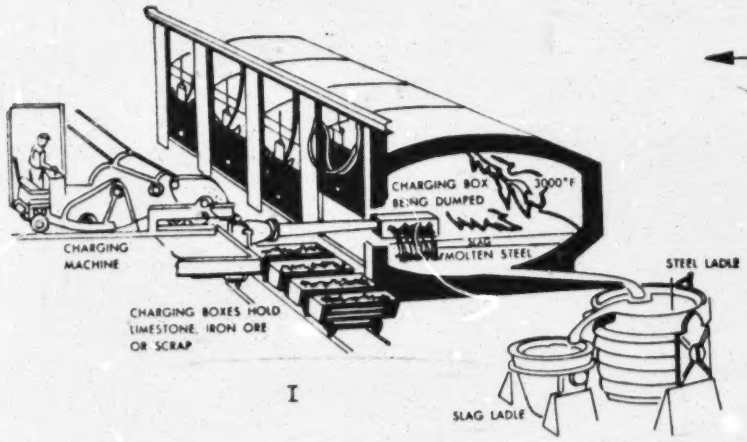
17. ____



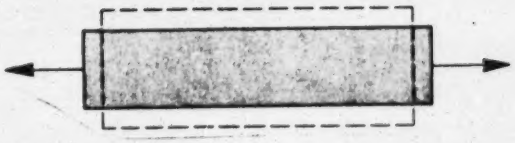
C



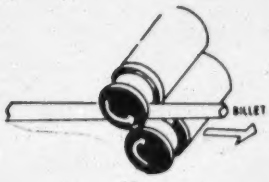
H


CHARGING BOX BEING DUMPED
3000°F
CHARGING MACHINE
MOLTEN STEEL
STEEL LADLE
CHARGING BOXES HOLD LIMESTONE, IRON ORE OR SCRAP
SLAG LADLE

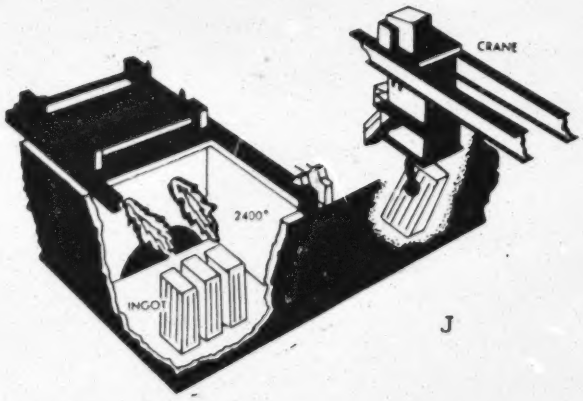
I



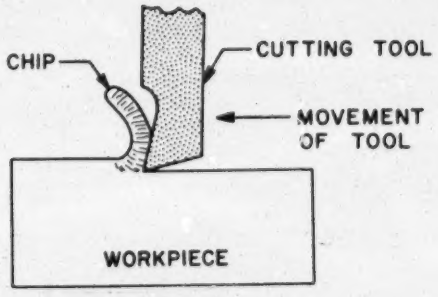
M


BILLET

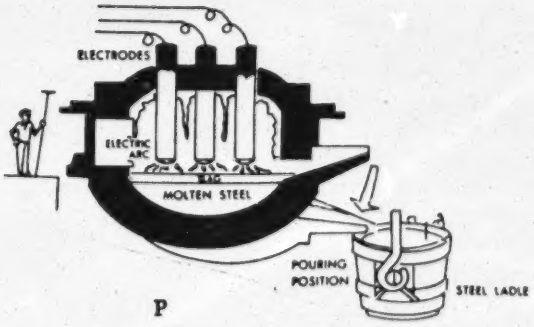
N


CRANE
2400°
INGOT

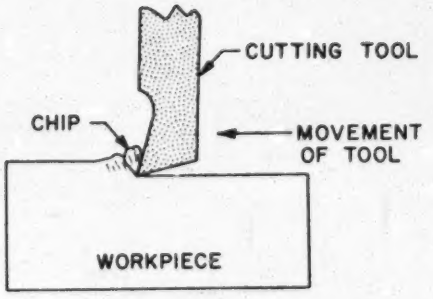
J


CHIP
CUTTING TOOL
MOVEMENT OF TOOL
WORKPIECE

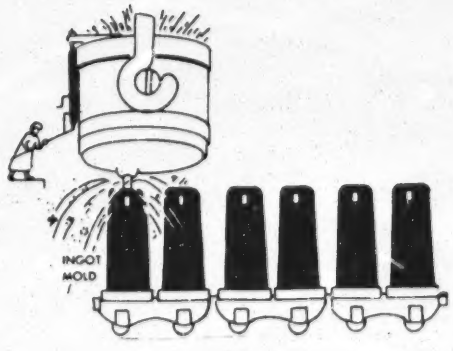
O


ELECTRODES
ELECTRIC ARC
MOLTEN STEEL
POURING POSITION
STEEL LADLE

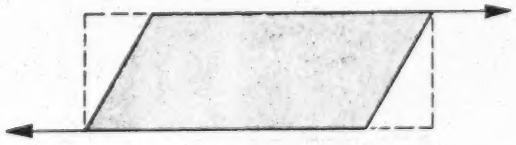
P


CUTTING TOOL
CHIP
MOVEMENT OF TOOL
WORKPIECE

K


INGOT MOLD

Q



L

ANSWER KEY TO QUINMESTER POST TEST

Multiple Choice

1. a	22. d	43. c
2. b	23. c	44. d
3. d	24. a	45. d
4. a	25. c	46. c
5. c	26. b	47. b
6. d	27. a	48. a
7. b	28. b	49. c
8. c	29. a	50. a
9. b	30. b	51. b
10. c	31. c	52. d
11. a	32. d	53. a
12. d	33. b	54. b
13. d	34. a	55. c
14. c	35. c	56. d
15. a	36. d	57. d
16. b	37. b	58. b
17. a	38. a	59. a
18. c	39. c	60. b
19. a	40. d	61. a
20. d	41. a	62. d
21. d	42. b	63. c

Identification

1. L
2. A
3. O
4. N
5. P
6. K
7. I
8. M
9. Q
10. B
11. H
12. C
13. J
14. G
15. F
16. E
17. D